

Turbulence as a Meteorological Agency.

Die Zirkulation der Atmosphäre in den gemässigten Breiten der Erde. Grundzüge einer Theorie der Klimaschwankungen. By A. Defant. Pp. 209-266. (Stockholm: Geografiska Annaler, 1921.)

THE study of turbulence as an agency of direct numerical importance in meteorological phenomena had its beginning before the war in the investigations of Åkerblom Hesselberg, G. I. Taylor, Barkow and W. Schmidt, and it is not surprising that it should have been developed independently on either side of the front during the war: on one hand by Taylor, L. F. Richardson, F. J. W. Whipple, D. Brunt, and H. Jeffreys, and on the other hand by W. Schmidt, F. M. Exner, and A. Defant. On both sides there has been the recognition of a common mathematical form of transmission upward or downward, through the agency of turbulence, of various elements with numerical coefficients that can be measured without entering into the details of the process by which the transmission is effected.

With us the study has been specially useful as applied to the eddy motion recognisable in winds and fogs, which is due to the friction of the ground and to the consequent deviation of the surface wind from the geostrophic wind; while on the other side the conception has tended to the general law of "Austausch," the passage upward or downward of heat or momentum in consequence of the ascertained conditions of equilibrium of adjacent columns. Both groups in different ways have come to recognise that transference by irregular turbulent motion is a principle of very general application, and that turbulence may range step by step, perhaps discontinuously, from the ultra-microscopic scale of molecular turbulence which we measure as viscosity to the gigantic scale of the eddy motion of the great cyclonic depressions or even of the general circulation of the whole atmosphere. L. F. Richardson has expressed the generality in a manner which easily sticks in the memory:—

Big whirls have lesser whirls that prey on their velocity;
They again have smaller whirls, and so on to viscosity.

In course of time we may have a view of the same idea of the universality of the ways of eddy motion from the Japanese point of view. The present article is concerned with an attempt on the part of Prof. A. Defant of Innsbrück to use the turbulence of the cyclonic depressions of middle latitudes to explain the distribution of temperature over the earth's surface and suggest explanations of climatic oscillations without entering at all into the details of the turbulent

motion by which the effects are produced. It is an important and suggestive chapter in a new volume of meteorological theory. It deals with *turbulente Strömung grossen Stils*, a greater scale than has been used hitherto. Its basis is an extension of Schmidt's idea of Austausch of mass, and its accompanying properties in the vertical, to the Austausch of mass in a horizontal surface along meridians in consequence of the turbulent horizontal motion which is expressed by the irregular barometric changes in middle latitudes, between 40° N. and 70° N. These are the first stages of smaller whirls on the back of the great general whirl, and we read, with some curiosity as to the further development of the next following stages, "Alle Druckstörungen pflanzen sich mit derselben Fortpflanzungs Geschwindigkeit der aussertropischen Zirkulation."

With the aid of an equation, belonging to what is now a recognised family, a formula is obtained for the normal flow of heat across a vertical square centimetre near the ground which, with an Austausch coefficient A equal to 10^8 gcm.⁻¹sec.⁻¹ gives a flow of heat northward of 100 gram calories per sq. cm. per minute. The value of A is supported by the integrated components of wind, north and south, at Potsdam, and we are allowed to infer that the general circulation of the atmosphere west to east goes on all the time and is crossed by a flow alternately north and south due to turbulence which on the average of the year gives the numerical result specified.

From that conclusion Defant proceeds to calculate the disturbance of surface temperature for latitudes north of 30° from the balance which would result from radiation alone; thence to calculate the distribution of temperature when the turbulence is taken into account and to compare the results with Hann's normal mean temperatures for successive latitudes. Finding that a uniform value for the coefficient of Austausch gives notable discrepancies, he adjusts the coefficient to bring calculation and observation into agreement, and thus arrives at the following values for A : 10^8 at lat. 30°, 5×10^8 from 40° to 65°, and 1.7×10^7 at 85°, with intermediate values for the intermediate latitudes; agreement being thus obtained, he claims that the variation of turbulence with latitude gives a satisfactory picture of the conditions so far as he knows them.

Having thus arrived at an explanation of the steady state, he proceeds to discuss the effect of a sudden permanent increase of temperature in the intertropical belt, such as might be assumed to represent the effect of the activity of sun-spots. He finds that the Austausch would cause a corresponding change of diminished amplitude with little difference of phase in more

northern latitudes, and finally discusses periodic alterations of the three elements upon which the distribution of temperature must be based, namely, the temperature of the intertropical belt, the radiative power of the air, and the intensity of the general circulation. He thus outlines a general theory of climatic changes.

The processes of reasoning are mathematical, and are set out with exemplary clearness; in order to get numerical results a great number of assumptions are necessarily made. So long as the discussion is confined to the consideration of the earth as a whole and normal temperatures are treated as a simple function of the latitude, a good deal of liberty may be allowed in the other assumptions; but when we get to close quarters with current meteorological experience some of them will naturally need adjustment. It seems odd that in dealing with periodic changes the best known periodic change from winter to summer did not challenge the author's curiosity. It seems nearer at hand than the influence of sun-spots or Brückner's cycle.

The justification for using the Austausch A as a numerical symbol of the effect of the whole irregular atmospheric motion of middle latitudes would be complete if it could be shown that its measure from time to time would do instead of the study of the motion itself. From that point of view the winds at Potsdam can be regarded only as a beginning, and not a very good one. The winds at Bergen would certainly tell a very different story. The next step appears to be a closer examination of some data for Austausch.

One more point is noteworthy. Prof. Defant is apparently under the impression that in consequence of the conservation of momentum winds of 300 m./sec. are a meteorological possibility from the occurrence of which we are saved by the turbulence of middle latitudes. What we thought to be the causes of our worst gales appear as our safeguard against being blown away completely by winds of tenfold velocity. But in our practice we have become accustomed to regard winds as inevitably related to pressure differences. Prof. Marvin, of the United States Weather Bureau, has recently pointed out that the idea of winds of 300 m./sec. is one of the common fallacies about the atmosphere that not even the *cognoscenti* have escaped, and that in face of the "geoidal slope" they could not occur, turbulence or no turbulence. It is, therefore, a little disconcerting to find that Prof. Defant deploys the power of the Austausch to destroy them: disconcerting for this reason, that we are apparently put in possession of an engine that is powerful enough to reduce winds of 300 m./sec. to 20 m./sec.

if it were wanted, and it is not wanted. What then becomes of its power? Has the power of the engine been over-estimated, or has it other work to do?

It is true that Prof. Defant's remark is merely an *obiter dictum*, and has no influence upon his reasoning; but the same idea stares one in the face from the diagrams of Ferrel, J. Thomson, and others, and is quoted by more recent authors. It is time it was cleared off the field of meteorological theory.

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Forensic Chemistry.

Forensic Chemistry. By A. Lucas. Pp. viii + 268. (London: Edward Arnold and Co., 1921.) 15s. net.

MR. A. LUCAS, who is the director of the Government Analytical Laboratory and Assay Office, Cairo, claims that his book is the first of its kind in English, with the possible exception of a small work on legal chemistry which he published in 1920, out of which the present work has grown. In a limited sense the claim may be valid, although the distinction between forensic chemistry and forensic medicine, on which latter subject there are many well-established treatises, is one of degree rather than of kind. Hitherto works on forensic medicine have included forensic chemistry. The expert on forensic medicine has usually been a medical man with knowledge and experience of the detection of chemical substances, such as poisons, which may form the subject of criminal investigation. Strictly speaking, the two branches are, however, perfectly distinct, and there has been a growing tendency within recent years to differentiate them. The criminal who contemplates murder, for example, has far more means at his disposal nowadays than formerly. Science has furnished him with methods unknown to former generations, and these can be combated and checked only by methods of science. It was inevitable, therefore, that public security should require the establishment of a special class of expert whose duty should be the study and application of methods of detection and recognition by chemical means of the many agents and appliances which may now form the subject of criminal inquiry.

But forensic or legal chemistry, as Mr. Lucas points out, may be concerned not only with examinations for the presence or absence of particular substances, such as poisons, but with questions which are only partly chemical, as the examination of blood-stains, questioned documents, counterfeit coins, fibres and textile fabrics—in fact, any problem of criminal